

# ANNEX P

## Sulfur Dioxide Emissions

Sulfur dioxide (SO<sub>2</sub>) emitted into the atmosphere through natural and anthropogenic processes affects the Earth's radiative budget through photochemical transformation into sulfate aerosols that can (1) scatter sunlight back to space, thereby reducing the radiation reaching the Earth's surface; (2) affect cloud formation; and (3) affect atmospheric chemical composition (e.g., stratospheric ozone, by providing surfaces for heterogeneous chemical reactions). The overall effect of SO<sub>2</sub> derived aerosols on radiative forcing is believed to be negative (IPCC 1996). However, because SO<sub>2</sub> is short-lived and unevenly distributed through the atmosphere, its radiative forcing impacts are highly uncertain. Sulfur dioxide emissions have been provided below in Table P-1.

The major source of SO<sub>2</sub> emissions in the United States was the burning of sulfur containing fuels, mainly coal. Metal smelting and other industrial processes also released significant quantities of SO<sub>2</sub>. As a result, the largest contributors to U.S. emissions of SO<sub>2</sub> were electric utilities, accounting for 67 percent in 1999 (see Table P-2). Coal combustion accounted for approximately 93 percent of SO<sub>2</sub> emissions from electric utilities in the same year. The second largest source was industrial fuel combustion, which produced 15 percent of 1999 SO<sub>2</sub> emissions. Overall, SO<sub>2</sub> emissions in the United States decreased by 20 percent from 1990 to 1999. The majority of this decline came from reductions from electric utilities, primarily due to increased consumption of low sulfur coal from surface mines in western states.

Sulfur dioxide is important for reasons other than its effect on radiative forcing. It is a major contributor to the formation of urban smog and acid rain. As a contributor to urban smog, high concentrations of SO<sub>2</sub> can cause significant increases in acute and chronic respiratory diseases. In addition, once SO<sub>2</sub> is emitted, it is chemically transformed in the atmosphere and returns to earth as the primary contributor to acid deposition, or acid rain. Acid rain has been found to accelerate the decay of building materials and paints, and to cause the acidification of lakes and streams and damage trees. As a result of these harmful effects, the United States has regulated the emissions of SO<sub>2</sub> under the Clean Air Act. The EPA has also developed a strategy to control these emissions via four programs: (1) the National Ambient Air Quality Standards program,<sup>1</sup> (2) New Source Performance Standards,<sup>2</sup> (3) the New Source Review/Prevention of Significant Deterioration Program,<sup>3</sup> and (4) the sulfur dioxide allowance program.<sup>4</sup>

## References

EPA (2000) *National Air Pollutant Emissions Trends Report, 1900-1999*, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC.

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<sup>1</sup> [42 U.S.C § 7409, CAA § 109]

<sup>2</sup> [42 U.S.C § 7411, CAA § 111]

<sup>3</sup> [42 U.S.C § 7473, CAA § 163]

<sup>4</sup> [42 U.S.C § 7651, CAA § 401]

Table P-1: SO<sub>2</sub> Emissions (Gg)

Sector/Source	1990	1995	1996	1997	1998	1999
<b>Energy</b>	<b>20,136</b>	<b>16,247</b>	<b>16,113</b>	<b>16,534</b>	<b>16,647</b>	<b>16,085</b>
Stationary Combustion	18,407	14,724	14,727	15,106	15,192	14,598
Mobile Combustion	1,339	1,189	1,081	1,116	1,145	1,178
Oil and Gas Activities	390	334	304	312	310	309
<b>Industrial Processes</b>	<b>1,306</b>	<b>1,117</b>	<b>958</b>	<b>993</b>	<b>996</b>	<b>996</b>
Chemical Manufacturing	269	260	231	235	237	238
Metals Processing	658	481	354	369	367	364
Storage and Transport	6	2	5	5	5	5
Other Industrial Processes	362	365	354	371	376	379
Miscellaneous*	11	9	15	14	11	11
<b>Solvent Use</b>	<b>+</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>
Degreasing	+	+	+	+	+	+
Graphic Arts	+	+	+	+	+	+
Dry Cleaning	NA	+	+	+	+	+
Surface Coating	+	+	+	+	+	+
Other Industrial	+	+	1	1	1	1
Non-industrial	NA	NA	NA	NA	NA	NA
<b>Agriculture</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>
Agricultural Burning	NA	NA	NA	NA	NA	NA
<b>Waste</b>	<b>38</b>	<b>43</b>	<b>37</b>	<b>37</b>	<b>38</b>	<b>33</b>
Waste Combustion	38	42	36	36	37	32
Landfills	+	+	1	1	1	1
Wastewater Treatment	+	1	+	+	+	+
Miscellaneous Waste	+	+	+	+	+	+
<b>Total</b>	<b>21,481</b>	<b>17,408</b>	<b>17,109</b>	<b>17,565</b>	<b>17,682</b>	<b>17,115</b>

Source: (EPA 2000)

\* Miscellaneous includes other combustion and fugitive dust categories.

+ Does not exceed 0.5 Gg

NA (Not Available)

Note: Totals may not sum due to independent rounding.

Table P-2: SO<sub>2</sub> Emissions from Electric Utilities (Gg)

Fuel Type	1990	1995	1996	1997	1998	1999
Coal	13,807	10,526	11,073	11,444	11,313	10,756
Petroleum	580	375	417	466	691	596
Natural Gas	1	8	6	5	5	11
Misc. Internal Combustion	45	50	48	51	52	53
Other	NA	NA	4	4	110	104
<b>Total</b>	<b>14,432</b>	<b>10,959</b>	<b>11,549</b>	<b>11,971</b>	<b>12,171</b>	<b>11,520</b>

Source: (EPA 2000)

Note: Totals may not sum due to independent rounding.